Hydrogen: Reality or Sci-fi?

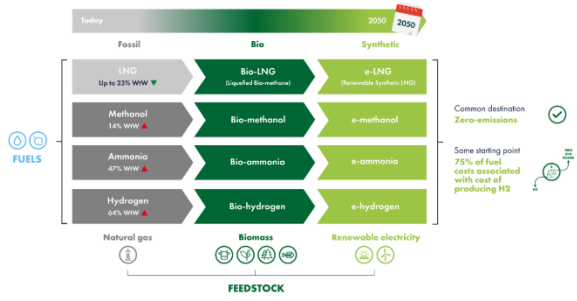
by Eliseo Curcio

Clean hydrogen and related technologies will play a key role in decarbonizing many sectors. The path is long but governments, institutions, private and public sectors, are moving in the right direction to make this a reality in the upcoming years. The refining sector accounts for the greatest share of hydrogen consumption in the United States. More than 60% of the total hydrogen demand is used mainly as a feedstock within the manufacturing and chemical industry. However, it shows great potentials for other sectors.

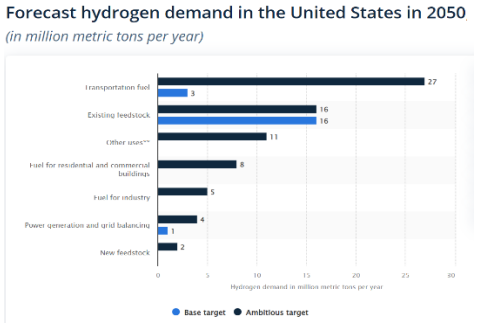
Despite hydrogen representing only 0.003% of global transport energy Hydrogen demand has increased 60% since 2020 and it is projecting to triple by 2040. In this sector hydrogen has a lot of potential, mainly because it can be used in ZEV to generate electricity and produce alternative fuels such as ammonia and methanol which will have market in the short term. Currently, hydrogen makes up a small share in the building and energy sectors, representing a mere 0.2% of global energy. This comes mostly from fossil fuels, but with current implementation of policies and investment, it will help hydrogen gain momentum; especially with the investments in solar, wind and electrolyzers. The technology which produces green hydrogen is still expensive and not sophisticated enough but it is expected to reach a full potential by 2040. At this time, we will see more incentives and an increase in the adoption of hydrogen. There are several reasons why hydrogen is already becoming a reality rather than just a science fiction idea.

1) Versatility

Hydrogen has immense versatility and can be used as the follows: direct fuel in internal combustion engines for the transportation industry, fuel cells, and a feedstock to produce alternative fuels (ammonia and methanol), power generation.

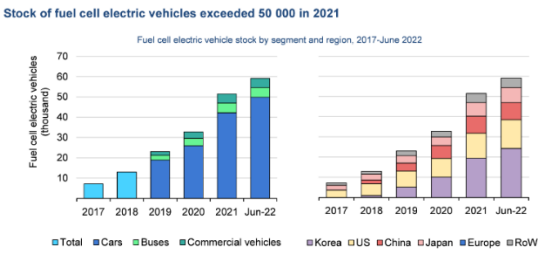


1: Different types of feedstocks to produce Hydrogen



2: Forecast Hydrogen demand in the U.S. in 2050 (source Statista)

Depending on the source of hydrogen adopted, we can have Hydrogen (fossil), bio-hydrogen (biomass) and e-hydrogen (renewable electricity). Hydrogen demand in the U.S. is projected to reach up to 73 million metric tons by 2050. The assumption is that as much as 27 million metric tons of hydrogen will be consumed in the automotive sector, either directly, fuel cells or other hydrogen derived. The post pandemic madness in addition with the Ukraine-Russia crisis, sped up the process of moving toward more reliable energy sources and in particular hydrogen and fuel cells.



3: Fuel cell electric vehicles in 2021 around the World (source IEA)

We can see from the above charts that the number of fuel cell vehicles has increased drastically since 2017, not only in North America but even in Korea. It will take some time for ZEV to become a reality taking into account the massive vehicle fleet that need to be up-grated Worldwide. Another issue in the short term is competition with biofuels such as Bio-ethanol and Renewable diesel that require less capital, less costs and minor change to infrastructures.

2) Policies and Investment from both private and public sectors

In order for a technology to gain momentum and take over more carbon polluting technologies, important initiatives (policies) and investments are needed from both private and public sectors. On the public side, the Biden-Harris administration has identified zero or low carbon hydrogen as a key element of its strategy for reaching net zero U.S. greenhouse gas emission by no later than 2050, and 100% carbon-free electricity by 2035. Even though this could be difficult to fully achieve, this gives a clear picture to the industry on where the government intends to arrive. The message is not only posted through policies but also through incentives.

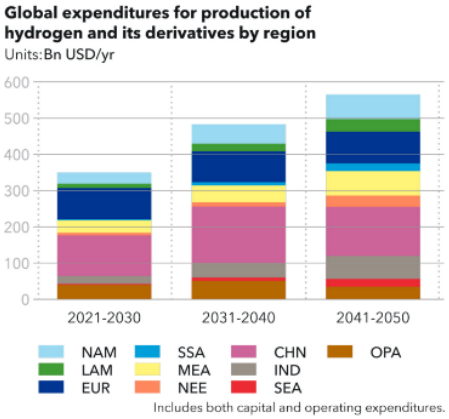
The U.S. department of energy opened applications for $7-8 billion program to create regional clean hydrogen hubs (H2Hubs) across the country, which will form a critical arm of America's future clean energy economy. The government also plans to implement tax credits for green hydrogen that for the would be more economical. In particular green hydrogen has the potential to be used as electricity and give incentives for whomever will use it. First, clean energy production and investment tax credits (for nuclear or electrolysis), these incentives will provide up to $3/kg of low-carbon hydrogen produced for 10 years. The third incentive applies to hydrogen used to generate electricity in combined-cycle plants.

This is an important step, currently hydrogen accounts for only ~1% of the energy mix and it is predominately produced using unabated fossil fuels, and is mainly used on-site where it is produced. Today, 95% of hydrogen is produced from fossil fuels, mainly natural gas (68%), oil (16%) and coal (11%), the rest is produced through renewables ways.

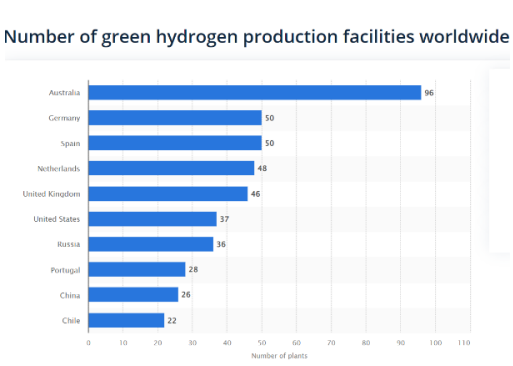
Even the EPA, is realizing the importance of hydrogen and electric cars, by proposing regulatory changes to include RINs from renewable electricity in the automotive sector. This would be an outstanding improvement by the EPA to start to give more credits for the creation and allocation of so called eRINs. In the private sector, more new hydrogen related companies have been formed in the last 3-4 years than in the previous 10 years combined; taking advantage of the subsidies from the government and states (in particular in OR, CA, WA because being part of the so-called clean fuel programs).

Even refineries start to realize the importance hydrogen will have in the future. For example, Exxon recently invested $7 billion dollar to develop a brand-new facility which will produce 1 billion cubic feet of low-carbon hydrogen daily. BP will invest up to $8 billion into transition growth engines by 2030 and in particular in hydrogen and renewables. If we look on the other side of the ocean, Saudi Arabia aims to be the World's leading Hydrogen exporter as it announced $266 billion clean energy plan. Europe is also catching up with the U.S. clean energy initiatives.

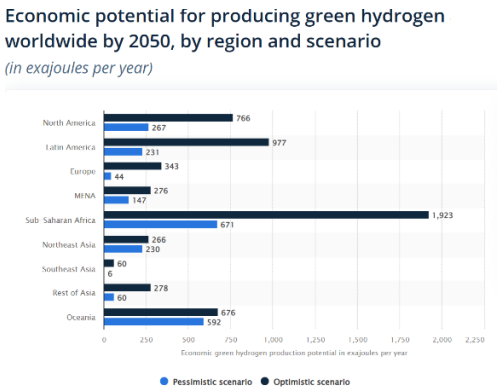
The renewable energy directive proposes a 45% renewable share of European energy use by 2030 and they aim for at least 40 GW electrolyser installed by 2030. Overall, the U.S. hydrogen market is forecasted to generate some $140 billion and creating more than 700,000 jobs in 2030. The amount of money could reach $750 billion by 2050 and would cover 14% of annual final energy demand. Let's have a look at the global expenditures for producing hydrogen and its derivatives around the World and the number of green hydrogen facilities worldwide (following charts):



4: Global Expenditures for producing Hydrogen (IEA)



5. Number of Green Hydrogen facilities (Source Statista)



6. Economic Potential for producing Green Hydrogen (Source Statista)

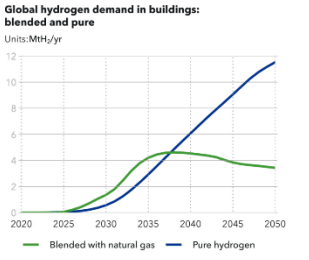
Australia is currently the country with the largest number of green hydrogen plants and that number is expected to triple by 2050. The reason is because the abundance of solar and wind. Besides Australia, EU is predominant with new policies and investment and US is expected to catch up. China is also heavily invested in producing hydrogen, betting fully that it will be the main chemical component adopted in the future. Africa, particularly the Sub-Saharan region, has immense potential to product green hydrogen due low hydrogen demand combined with its abundance of solar and wind resources. Africa has the possibility of producing lots of hydrogen at the lowest cost.

3) Demand, price and availability

Currently Hydrogen is still relatively too expensive to be widely used but with the help of policies and investments from both the private and public sectors, is going towards the right path.

	Technology	*H2 [$/Kg] 2020*	*H2 [$/Kg] 2030*	*H2 [$/Kg] 2050*
North America	SMR	1.51	1.8	2.3
North America	Renewable	6.23	2.8	2.1

7: Hydrogen forecast prices for different technologies



8: Hydrogen demand in building for the next years (Source DNV)

The cost of dedicated renewables-based electrolysis today is above $6/KgH2, but around 2030, we will see a sharp reduction in the cost of electrolysis with dedicated solar or wind capacity reducing considerably. The main driver of this trend will be the reduction of 40% in solar panel costs and 27% reduction in turbine costs. The other driver will be having a more mature technology available in conjunction with more stringent policies and taxes that will reduce the market price.

Around 2050, more than half of U.S. refineries would have invested and operating new low-carbon green hydrogen plants and eventually the price will assess to be comparable with the traditional SMR. At that point hydrogen will be used not only for the mobility industries but also as energy. Beside the energy sector, Hydrogen is also projected to be used in buildings. In the beginning as a blend component together with natural gas till the cost of hydrogen will reduce and will be more economically available.

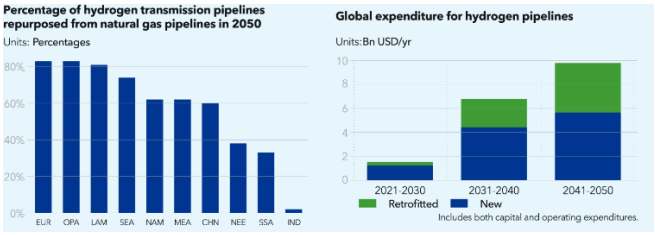
4) Infrastructure available

The infrastructure represents one of the major issues related with Hydrogen. Assuming that the majority of hydrogen will be moved in a liquid phase, this poses some drawbacks. NASA reported that for the space shuttle launch, 45%vol of purchased liquid hydrogen was lost in the process chain, before reaching the fuel tank of the space shuttle. Then 12.6% vol was lost due to transport from the onsite storage tank to the space shuttle fuel tank. Since the liquefaction process for hydrogen is an energy intensive processes the loss of liquid hydrogen must be reduced as much as possible to keep the overall energy efficiency of the process as high as possible.

Thereare expected to be up 4300 large hydrogen fueling stations in the U.S. by 2030. This would be almost 70 times the number of operational large fueling stations in 2019. Material-handling fueling stations are forecasted to grow to some 1500 in number. By 2050, transportation fuels are expected to account for the greatest volume of U.S. hydrogen demand (mentioned at point 1). Possibility of leaks is not only the main issues, but also safety is a major concern. Potential explosions could be more catastrophic compared with other fuels such as gasoline and diesel. Another possibility could be to transport Hydrogen as a methanol or ammonia.

Methanol (bio-methanol or e-methanol) in particular could be a great method because its less dangerous compared to pure hydrogen and ammonia. Because the high volatility, moving hydrogen is not easy. Creating a brand-new network of pipelines to accommodate the harsher chemical is not economical, because of the stringent thermodynamic conditions.

One possibility would be to adapt the current natural gas lines. The cost considerations will lead to more than 50% of hydrogen pipelines globally being repurposed from natural gas pipelines over the next decades, with the share as high as 80% in some regions. The cost to repurpose pipelines is expected to be just 10-30% of new construction costs.



9: Expenditure for Hydrogen Pipelines (Source DNV)

On the seaborne side, it is a bit more complex. Currently only very small amounts of liquid hydrogen are being transported by ship. For the aforementioned issues. The best way of transporting Hydrogen is using the already existing global value chain for seaborn transport of ammonia. This also will lower the cost of handling and storing because a less volatile component.

The seaborn issue will be extensively solved by the upcoming years, since the entire marine industry is investing massively on methanol, ammonia. Overall hydrogen is set to control the energy sector and it will be traded as a commodity. Goldman and Sachs expects that Hydrogen could become $1 Trillion per year market, creating jobs.

References:

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